THE SOIL ACIDITY AS RESTRICTIVE FACTOR OF THE USE OF NITROGEN FERTILIZER BY SPRING BARLEY

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Summary

In two - year micro - plot trials was studied the effect of soil pH value (pH > 6,5 and pH < 4,5) and application of ammonium sulphate (25 atm . % ^{15}N in first year and no enriched in second year, rates of 0, 85, 170 and 255 mg N per pot, i.e. 0, 30, 60 and 90 kg $N.ha^{-1}$) on the spring barley productivity and on the use of nitrogen fertilizer by plants in the application year of ^{15}N and in the following year.

The productivity of spring barley is significantly higher in neutral soil than in acid soil. The gradated rates of nitrogen fertilization increased this difference. The total nitrogen uptake by plants was higher in neutral soil. The share of the nitrogen from „the old soil´s supply" in the total uptake by the harvest ranges from 95 to 82 % and is practically identical in studied soils. „Priming effect" was higher in soil with better fertility (153 – 186 mg N per pot) than in acid soil (to 49 mg N per pot only). The gradated rates of ammonium sulphate increased the uptake nitrogen from fertilizer by harvest of spring barley in the application year of ^{15}N from 39 mg N to 107 mg N per pot in neutral soil and from 26 mg N to 83 mg N per pot in acid soil and in the following year from 3,05 mg N to 8,15 mg N per pot in neutral soil and from 1,76 mg N to 3,37 mg N per pot in acid soil. The total balance of fertilizer nitrogen (^{15}N) in soil – crop system in two years from application showed that in neutral soil 46% used by spring barley (42% in the application year and 4 % in the following year), 16% rested in soil and loss was 38% and in acid soil 35% used by harvest (33% in first year and 2% second year), 12% rested in soil and loss was 53%.

spring barley, acid soil, neutral soil, nitrogen fertilizer, soil nitrogen, nitrogen balance

1. Introduction

The use and the balance of nitrogen in system soil – plant with respect for conservation of life environment and economical use of fertilizer nitrogen is a very important problem in agrochemical and physiological research.

The productivity of agricultural plants is influenced by soil fertility, which is represented e.g. by humus content in soil, contents of available nutrients and, of course, soil pH value. The effect of soil pH level on processes in soil is in tight correlation with capability of soil to provide plants with mineral elements. That is why for better and effective application of nitrogen fertilization is very important to observe the influence of soil acidity on the use of fertilizer and soil nitrogen by plants.

We tacked this questions:

1. The effect of soil acidity and gradated nitrogen rates on the spring barley productivity;
2. The uptake nitrogen from fertilizer and soil nitrogen by the harvest and their role in productivity of spring barley in neutral soil and in acid soil;
3. The effect of soil pH level on the use of nitrogen fertilizer by spring barley in the application year and in the following year;

4. The balance of fertilizer nitrogen in the application year and in the following year on neutral soil and on acid soil.

2. Material and Methods

In the years 1997 and 1998 was studied the effect of soil pH value and gradated rates of nitrogen fertilizer on spring barley productivity and on the use of nitrogen fertilizer by harvest in the application year and in the following year. Spring barley, Jubilant variety, was grown in small - plot field trials in pots (area 1/35 m^2 and 30 cm high) without bottom recessed in soil profile at the experimental station in Polabska lowland in central Bohemia. It was by 15 plants per pot. Two experimental soils had medium humus content, medium contents of available phosphorus, potassium and magnesium and distinct pH level: neutral soil had pH > 6,5 and acidic soil had pH < 4,5.

The experiment included four variations, each repeated five times. The control set of plants was fertilised only with phosphorus (255 mg per pot) and potassium (320 mg per pot) in the form of potassium dihydrogenphosphate. The other three variations contained in addition to increasing supplies of nitrogen fertilization in the form ammonium sulphate (rates of 85, 170 and 255 mg N per pot, i.e. 30, 60 and 90 kg N .ha^{-1}). Ammonium sulphate was enriched 25 % by stable isotope ^{15}N in 1997 year and no enriched in 1998 year. All fertilizers were applied in the form of a solution mixed with the whole volume of the soil prior to filling the pots.

After harvest, the grain, straw and soils were analysed for percentic contents of total nitrogen using the Kjeldahl method and for isotope composition was using of spectral emission method on NOI - 6 in Saxon Provincial Institute for Agriculture in Leipzig.

3.Results and Discussion

It follows from the results in Tables I and II that the productivity of spring barley (the grain and straw yields) is significantly higher in neutral soil than in acid soil. Depresive function of low pH level didn't eliminate supply of nitrogen fertilizer because their gradated rates increased this difference.

Tab. I : The effect of soil pH value and gradated nitrogen rates on the yield of spring barley grain (in grammes per pot)

Soil	Variants of trial	Yield of grain 1997	Yield of grain 1998	Average values for two years
Neutral soil	**Control**	22,0	20,2	**21,1**
	N 85	28,8	23,8	**26,3**
	N 170	32,8	32,4	**32,6**
	N 255	36,2	37,3	**36,8**
Acid soil	**Control**	15,0	16,5	**15,8**
	N 85	19,0	20,4	**19,7**
	N 170	18,8	22,7	**20,8**
	N 255	18,0	17,3	**17,7**

Tab. II : The effect of soil pH value and gradated nitrogen rates on the yield of spring barley straw (in grammes per pot)

Soil	Variants of trial	Yield of straw 1997	Yield of straw 1998	Average values for two years
Neutral soil	Control	24,2	26,4	25,3
	N 85	35,6	29,8	32,7
	N 170	36,4	37,3	36,9
	N 255	36,2	40,8	38,5
Acid soil	Control	20,4	19,6	20,0
	N 85	25,6	24,0	24,8
	N 170	25,8	28,8	27,3
	N 255	23,0	22,0	22,5

While in the case on control variant in neutral soil a two years average yield of grain was 21,1 g per pot and nitrogen fertilization increased the yields on 26,3 g with rate of 85 mg N, 32,6 g with rate of 170 mg N and 36,8 g of grain with rate of 255 mg N per pot, the yield of grain in acid soil was 15,8 g per pot on control variant and 19,7 g , 20,8 and 17,7 g per pot with nitrogen fertilization. The most efficient in neutral soil are a rates of 30 and 60 kg $N.ha^{-1}$, but statistically significantly efficient is a rate 90 kg $N.ha^{-1}$, also. Statistically significantly efficient in acid soil is a rate of 30 kg $N.ha^{-1}$, only. The variability of yield didn't significantly influenced by the years. The similar results was reached in the yield of straw.

Significantly the greatest part from the variability of the total nitrogen uptake by harvest of spring barley (Tab. III) had the soil pH value and years. The effect of fertilizer nitrogen rates was significant on neutral soil and statistically non significant on acid soil.

Tab. III : The total nitrogen uptake by harvest of spring barley (in mg per pot)

Soil	Variants of trial	Total N uptake by harvest 1997	Total N uptake by harvest 1998	Average values for two years
Neutral soil	Control	666	452	559
	N 85	925	594	760
	N 170	949	691	820
	N 255	1073	581	827
Acid soil	Control	631	441	536
	N 85	666	539	603
	N 170	656	638	647
	N 255	597	347	472

The results of our experiment in Table IV showed, that the role of the nitrogen from „the old soil's supply" in production of spring barley yield is a very high. The share of this nitrogen in the total uptake by the harvest of spring barley ranges from 95 to 82% and is practically identical in studied soils. With growing rates of nitrogen fertilization the share of nitrogen from soil's supply decreases. Nitrogen fertilization leads to increased

uptake of soil nitrogen by plants. This so - called „priming effect" is higher in soils with better fertility and it reached 153 - 186 mg N per pot in neutral soil and to 49 mg N per pot only in acid soil.

Tab. IV : The uptake of fertilizer and soil nitrogen by harvest of spring barley (in mg per pot)

Soil	Variants of trial	Average values of total N uptake for two year	N uptake from fertilizer			N uptake from "the old soil's supply"	Share of soil N (%)	"Priming effect"
			in the application year	in the following year	total			
Neutral soil	Control	559	-	-	-	559	100	-
	N 85	760	39,0	3,05	42	718	94	159
	N 170	820	70,0	5,40	75	745	91	186
	N 255	827	107,0	8,15	115	712	86	153
Acid soil	Control	536	-	-	-	536	100	-
	N 85	603	26,0	1,76	28	575	95	39
	N 170	647	59,0	2,72	62	585	90	49
	N 255	472	83,0	3,37	86	386	82	-

The use of nitrogen from fertilizer by spring barley is higher in soil with neutral pH level compared with the soil of low pH level and the gradated rates of ammonium sulphate increased the uptake nitrogen from fertilizer (^{15}N) by harvest of spring barley in the application year from 39 mg N to 107 mg N per pot in neutral soil and from 26 mg N to 83 mg N per pot in acid soil and in the following year after application of ^{15}N from 3,05 mg N to 8,15 mg N per pot in neutral soil and from 1,76 mg N to 3,37 mg N per pot in acid soil.

Tab. V : The remainder of fertilizer nitrogen in soil after harvest of spring barley (in mg per pot)

Soil	Variants of trial	In the application year	In the following year
Neutral soil	Control	-	-
	N 85	22	15
	N 170	44	27
	N 255	61	37
Acid soil	Control	-	-
	N 85	14	11
	N 170	27	22
	N 255	35	29

The balance of fertilizer nitrogen (^{15}N) in soil - crop system in the application year (Tab. VI and Fig. 1) show that in neutral soil average 42% of ^{15}N used by spring barley, 25% rested in soil and loss was 33%. The similar results obtained also Khalil et al. (1997) in balance of ^{15}N in a sandy loam soil / spring wheat system. The results

confirmed also the conclusions of our previous work in balance of nitrogen fertilizer in system spring barley/ soils with neutral pH value and various humus content (Hejnák et al., 1997, Hejnák, Lippold, 1998). The balance in acid soil show that 33% used by harvest, 15% rested in soil and loss was 52% and this results correspond with our previous experiment on this acid soil (Hejnák, Lippold, 1998).

Tab. VI : The balance of fertilizer nitrogen (^{15}N) in soil – crop system in the application year on soils of various pH value (in % of supplied nitrogen)

Soil	Variants of trial	Intake by plants	Rest in soil	Not found
Neutral soil	N 85	46	26	28
	N 170	41	26	33
	N 255	42	24	34
Acid soil	N 85	31	16	53
	N 170	35	16	49
	N 255	33	14	53

In field trials of Timmons and Cruse (1991) the soil profile was sampled periodically to measure residual ^{15}N in the organic and inorganic pools. One year after application 16 - 27% of ^{15}N was found in the organic N pool and only 1% as inorganic N(NH_4^+, NO_2^- and NO_3^-). After four seasons, residual ^{15}N in the organic N pool ranged from 13 to 24%. Less than 0,5% remained as inorganic N. In our experiment the balance of fertilizer nitrogen (^{15}N) in soil - crop system in the following year in % from remainder of ^{15}N in soil after first year (Tab. VII and Fig. 2) show that average in neutral soil 13% used by spring barley, 62% rested in soil and loss was 25% and in acid soil 10% used by spring barley, 81% rested in soil and loss was 9% only. The high value of the rest, the low value of the use and the low value of the loss in acid soil in the following year showed on a low microbial activity of this soil.

Tab. VII : The balance of fertilizer nitrogen (^{15}N) in soil – crop system in the following year on soils of various pH value (in % from remainder of ^{15}N in soil after first year)

Soil	Variants of trial	Intake by plants	Rest in soil	Not found
Neutral soil	N 85	14	68	18
	N 170	12	61	27
	N 255	13	61	26
Acid soil	N 85	13	78	9
	N 170	10	81	9
	N 255	10	83	7

The total balance of fertilizer nitrogen in soil crop system in two years from application (Tab. VIII and Fig. 3) show that average in neutral soil 46% of supplied nitrogen used by spring barley (42% in the application year and 4% in the following year), 16% rested in soil and loss was 38% and in acid soil 35% used by harvest (33% in first year and 2% second year), 12% rested in soil and loss was 53%. The similar results

Fig 1: The balance of fertilizer nitrogen (^{15}N) in soil – crop system in the application year on soils of various pH value (average value from various nitrogen fertilizer rates in % of supplied nitrogen)

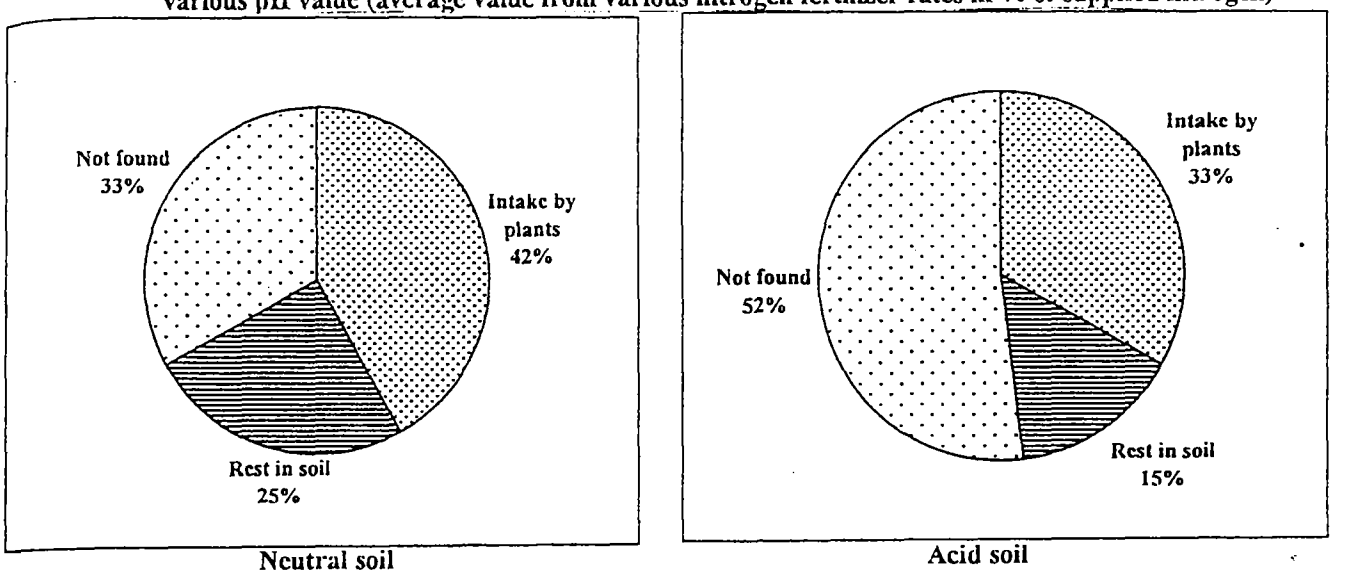


Fig 2 : The balance of fertilizer nitrogen (^{15}N) in soil – crop system in the following year on soils of various pH value (in % from remainder of ^{15}N in soil after first year)

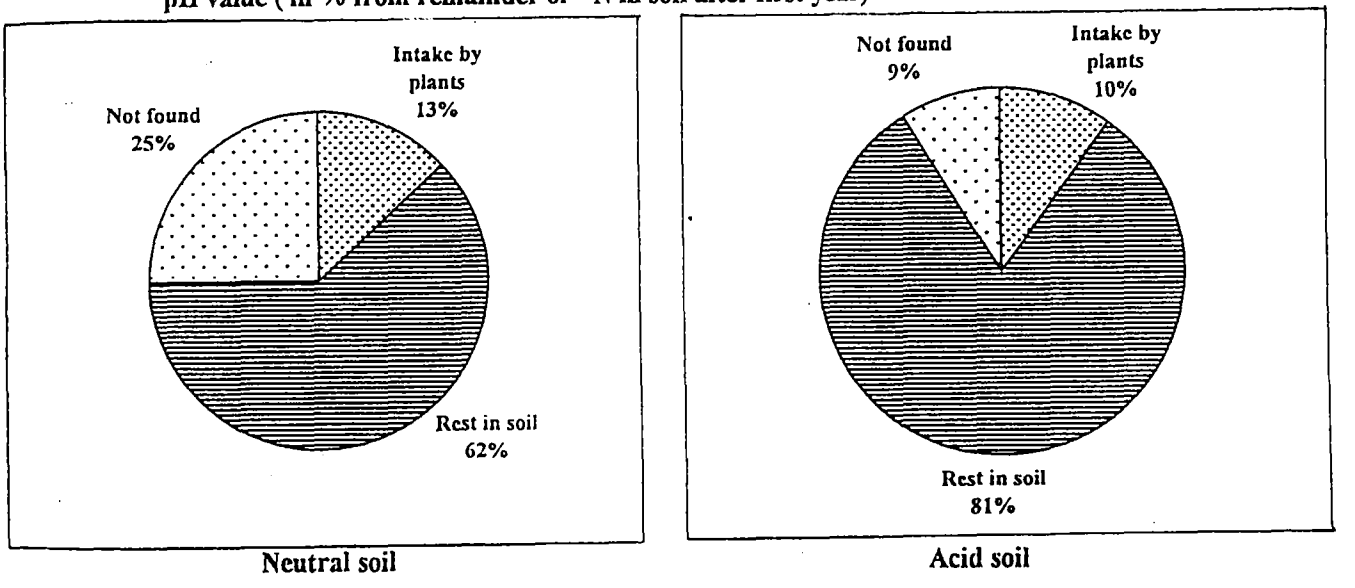
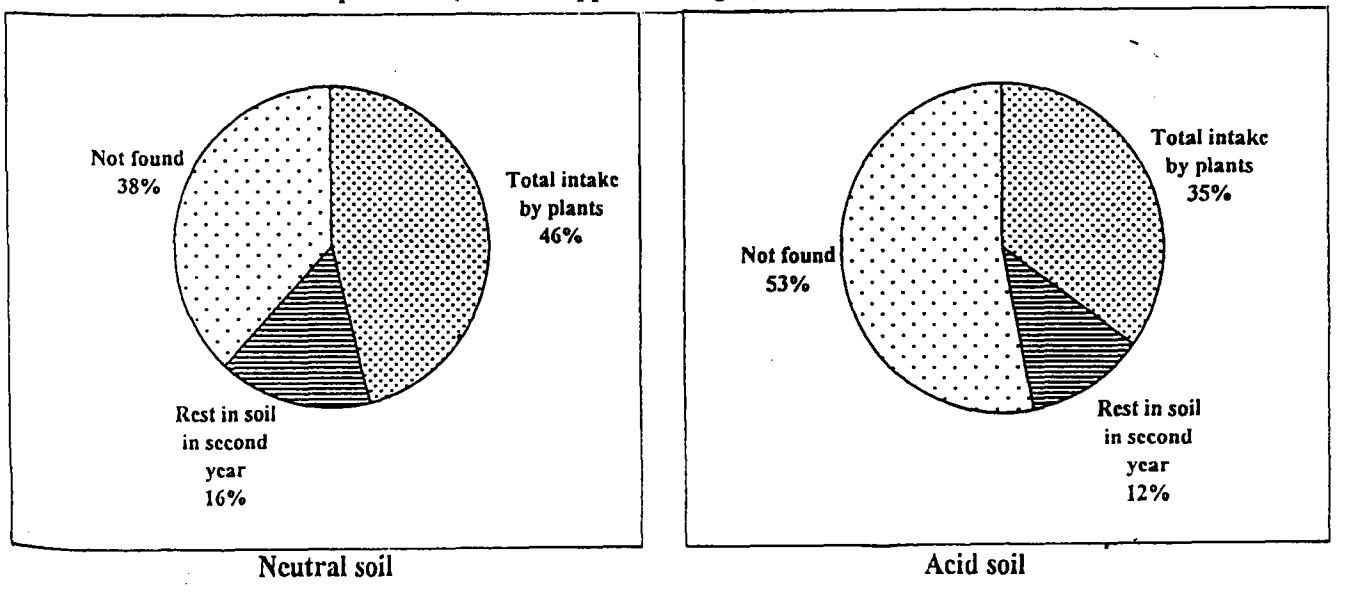


Fig 3 : The total balance of fertilizer nitrogen (^{15}N) in soil – crop system in two years from application on soils of various pH value (in % of supplied nitrogen)



Tab. VIII : The total balance of fertilizer nitrogen (^{15}N) in soil – crop system in two years following application of ^{15}N on soils of various pH value (in % of supplied nitrogen)

Soil	Variants of trial	Intake by plants			Rest in soil after harvest in second year	Not found
		in the application year	in the following year	total		
Neutral soil	N 85	46	4	50	18	32
	N 170	41	3	44	16	40
	N 255	42	3	45	15	40
Acid soil	N 85	31	2	33	13	54
	N 170	35	2	37	13	50
	N 255	33	1	34	11	55

obtained also Bradbury et al. (1993) in modelling the fate of nitrogen in crop and soil in the years following application of ^{15}N - labelled fertilizer to winter wheat.

4. Conclusions

1. The productivity of spring barley is significantly higher in neutral soil than in acid soil.
2. The gradated rates of nitrogen fertilization increased this difference. Statistically significantly efficient are in neutral soil a rates of 30 - 90 kg N. ha^{-1}, in acid soil a rate of 30 kg N.ha^{-1} only.
3. The share of the nitrogen from „the old soil's supply" in the total nitrogen uptake by the harvest of spring barley was between 95 - 82% and was practically identical in studied soils.
4. The nitrogen fertilization increased uptake of soil nitrogen by plants. „Priming effect" was higher in soil with better fertility.
5. The use of nitrogen from fertilizer by spring barley was higher and loss was lower in neutral soil than in acid soil in two years following application of ^{15}N.

5. References

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